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[21] Bray and Branch, *Ibid.*, **35,** 1915, 1913, (1440).

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TRANSVERSE DISPLACEMENT INTERFEROMETRY

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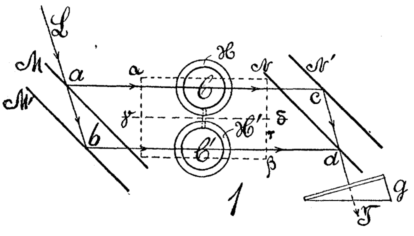
Communicated March 26, 1917

1. Vertical Displacement of Ellipses.—In the diagram figure 1, M and N are half silvered, M' and N' opaque mirrors; C and C' the U tube referred to in the preceding note and here to be removed. L is the collimated beam of white light and G T the direct vision spectroscope.

If the fringes are too small, when horizontally centered by the micrometer, the center of ellipses may be brought into the middle of the field of the telescope by sliding one component beam vertically over the other without appreciably changing the direction of the rays. In other words one illuminated spot at d, figure 1, is to move vertically relative to the other by a small amount. This may be done by placing a thick plate glass compensator such as is seen in figure 2 in each of the component beams abd and acd and suitably rotating one plate relative to the other, each on a horizontal axis. Very little rotation is required. In the same way elliptical fringes may be changed to nearly linear horizontal fringes when desirable. If the fringes are to be sharp the slit must be very fine. When sunlight is used with a slit not too fine, each of the coincident sodium lines (D_1D_2) frequently shows a sharply defined helical or ropelike structure. This is a special phenomenon, which will be given further consideration presently.



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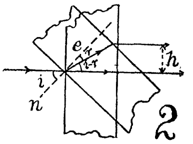

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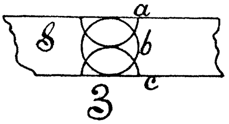

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The first result is interesting inasmuch as it is thus possible to displace the centers of ellipses not only horizontally as usual relative to the fixed sodium lines in the spectrum, but also *vertically* relatively to the fixed horizontal shadow in the spectrum due to the fine wire across the slit. It does not occur when rays retrace their path. The following experiment was made to coordinate the vertical displacement of the component rays and centers of elliptic fringes. A glass plate $d=0.705$ cm. thick was placed nearly normally in the beam *bd*, figure 1, and provided with a horizontal axis and graduated arc. The amount (i) of rotation of the plate, corresponding to the vertical displacement of one central fringe in the telescope (i. e., the passage of the ring *a*, into *b* and then into *c*, in the spectrum, S, figure 3) was then found to be, if i is the angle of incidence,

	i	h	Δh
No fringes, *c* fig. 3	3.5°	0.0149 cm.	....
One fringe, *b* fig. 3	5.0°	0.0214	0.0065 cm.
Two fringes, *a* fig. 3	6.5°	0.0281	0.0067

where h is the corresponding vertical displacement of the rays *bd* (see figure 2) and computed from (μ index, r angle of refraction)

$$h = d\,(\sin i - \cos i \tan r)$$

Thus the vertical displacement of rays corresponding to the vertical semiaxes of the central ellipse or one fringe is between 0.0065 to 0.0067 cm., i. e., a superior limit would be about 7×10^{-3} cm. Hence $h = N\ 0.007$ for N such central fringes is an excessive estimate.

The question is now suggested, in how far such an arrangement would fall short of being able to exhibit the drag of the ether in a rapidly rotating body, should such drag occur. In figure 1, let $\alpha\ \beta$ be a cylinder of glass with plane parallel ends, capable of rotating on the axle $\gamma\ \delta$. If l is the length of the cylinder μ its index of refraction, and and r the distance of either component ray (*ac*, *bd*) from the axis $\gamma\ \delta$, n the number of turns per second and V the velocity of light, we may write using the above estimate, N being the number of fringes displaced

$$h = \tfrac{1}{2} N \times 0.007 = 2\,\pi\,n\,r\,l\,\mu/V$$

since *ac* rises while *bd* falls. If $n = 200$, $r = 10$ cm., $1 = 100$ cm, $V = 3\times 10^{10}$, $\mu = 1.5$

$$N = 0.018, \text{ nearly.}$$

It would thus be necessary to estimate about 1/60 of a fringe, which is just beyond the limit of certainty even if n, r can be increased, and l multiplied by reflection. The device suggested is nevertheless of interest and deserves further consideration. In fact I have succeeded in increasing the sensitiveness about four times.

2. Displacement Interferometer. Jamin Type.—These considerations induced me to devote further study to the Jamin type of interferometer, figure 1. The mirrors *M*, *N′* were put on one pair of long slides (1.5 meters long) parallel to *ac* and the mirrors *M′ N* on similar slides parallel to the former. In this way any distance *ac* or *bd* was available. The beams were about 16 cm. apart corresponding to a normal distance between the end mirrors (*N N′*, *M M′*) of about 12 cm. But these distances could also be increased from nearly zero (*M* and *M′* nearly contiguous) to about 20 cm. in view of the width of mirrors used. The angles at *a*, *b*, *c*, *d* were each about 45°, so that a rectangle of rays is in question.

The adjustment proved eventually to be quite simple by aid of a horizontal beam of sunlight with *weak* condenser lens and collimator. A thin wire is to be drawn across the slit. *M* and *M′* are first set for parallelism in the absence of *N* and *N′* by adjusting the images of the slit at the same level (horizontal) and equidistance on a distant wall. The mirrors *N* and *N′* are next put in place with the distances *acd* and *abd* about equal. The two images seen in the telescope at *T* (*g* removed) are then made to coincide both horizontally and vertically by adjusting *N* and *N′* and these are then slid by a small amount on their slides (direction *ac*) until the rays are coincident at *d* to the eye (light strips on the mirror coincide).

If now the grating *g* is inserted very, fine oblique fringes will usually be seen. These may be enlarged to a maximum by moving the micrometer controlling the displacement *M′* normal to itself. Somewhat coarser *horizontal* lines are thus obtained.

Finally the distant centers of the ellipses are brought into the center of the telescope by aid of the thick glass compensator (figure 2), (the equivalent air path of the other ray being correspondingly lengthened), by rotating the glass plate on a horizontal axis. The same result may be obtained by rotating *N* and *N′* on a horizontal axis, successively by small amounts, into parallelism with *M* and *M′*. But the compensator is more convenient.

The ellipses so obtained with common plate glass and a film grating at *g* were magnificent. A rough test of the diplacement interferometer was made by using the above plate glass of thickness $E = 0.434$ cm. where $z = E(\mu - 1) + 2B/\lambda^2 = 0.2428$ cm. In two experiments agreeing to within 10^{-4} cm., $2e = 0.3448$ cm. were the displacement obtained. Assuming that $\theta = 45°$, $2e \cos \theta = 0.2438$ cm. This agrees with z as nearly as may be expected unless θ is specifically measured.

3. Broad Slit Interferences. White Light. Residual Fringes.—Some allusion has been made above to a type of interferences, totally different in size from the regular fringes, and seen in the broadened slit. These were finally isolated. They appear to best advantage in the absence of the spectroscope, in the broad *white* field of a very wide slit. The latter may be removed. They have the appearance when vertical of regular Young or Fresnellian fringes, very sharp and fine, achromatically black and white at the middle of the grid, colored and fainter outward. They are vertical when the enormously larger spectrum ellipses discussed above are centered. Like these they partake of displacement, here through the broad white slit image and this displacement is extremely sensitive in relation to the displacement of the opaque mirror M' (fig. 1) to which it is due. Thus a displacement of $\Delta N = 10^{-4}$ cm. of the latter, corresponded to a march of fringes through about .017 of the telescopic field of 3°, i.e. to 0.05°. This comprises two fringes or $\Delta N = 5 \times 10^{-5}$ cm. per fringe. Now these fringes are so fine, sharp and luminous that it should be possible on proper magnification to measure a few hundredths of this with an ocular micrometer. They supply the fine fiducial mark in displacement interferometry for which I have long been seeking. They appear in a white field, thus requiring no spectrum resolution, nor monochromiatc light. Moreover the source of light need not be intense.

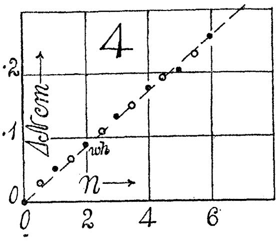
I shall in referring to the new fringes use the term residual or achromatic fringes. Their theoretical breadth should be $\Delta N = \lambda / 2 \cos \theta$ agreeing substantially with the given estimate.

The displacement of fringes with ΔN at the mirror (when $n \lambda = \Delta N \cos \theta$) is so rapid that if they are lost it is difficult to find them, unless the centered large fringes in the spectroscope are first reëstablished. The latter are easily found. A removal of the prism grating gT, figure 1, and widening of the slit shows the achromatic fringes. The white pattern usually appears but once and is rarely present rhythmically as in the case of the next section for homogeneous light.

4. Wide Slit. Homogenous Light. Sodium Flame.—A clue to the nature of the residual fringes will be obtained when white light is replaced by homogeneous light. A strong large sodium flame near the mirror M, figure 1, suffices. The fringes now appear of the same size in yellow light and naturally spread over a much larger area of field. But on moving the mirror (ΔN increasing continually) forward very gradually, the homogeneous fringes alternately vanish and reappear, each time however enlarged in size but still straight, until at an intermediate position of symmetry enormous round ovals cover the yellow field. The fringes then diminish symmetrically in the same way. The following data for the micrometer position corresponding to the clearest demarcations of yellow fringes are illustrative. At least six periods (n) are easily detected in each side of the ovals ($n = 0$) Thus,

n	6	5	4	3	2	1	0 etc.
$\Delta N \times 10^3$	0	49	90	127	171	214	243 cm. etc.

These intervals, since it is impossible to establish the maximums states of presence or absence of fringes quite sharply, are practically equidistant as the similar series in figure 4 indicates. Fringes in presence are here shown by black dots, the circles denote clear fields. Thus the mean period of reappearance is $\Delta N = 0.042$ cm.; or a path difference of $2 \Delta N \cos \theta = 0.059$ cm; or a shift of ray parallel to itself ($2 \Delta N \sin \theta = 0.059$ cm.) of the same amount.



The reason for this rhythm can only be the two wave lengths of the D_1 and D_2 lines of the sodium flame, originally detected in the colors of thin plates by Fizeau. Hence a relatively enormous shift of micrometer of nearly half a millimeter is equivalent to the wave length interval $\Delta \lambda = 6 \times 10^{-8}$ cm.; or $\Delta \lambda / \Delta N = 6 \times 10^{-8} / 42 \times 10^{-3} = 1.4 \times 10^{-6}$. Treating the case in terms of the interferences of thin plates and two wavelengths λ and $\lambda + d\lambda$

$$n\lambda = \text{constant, or } \frac{\Delta\lambda}{\lambda} = \frac{\Delta n}{n} = \frac{1}{n} \text{ for each period.}$$

Hence $$n\lambda = \frac{\lambda^2}{\Delta\lambda} = 2\Delta N \cos\theta \quad \text{or} \quad \Delta N = \lambda^2/2\Delta\lambda \cos\theta$$

since ($\theta = 45°$) approximately $\lambda = 60 \times 10^{-6}$ cm. $\Delta \lambda = 6 \times 10^{-8}$ cm.
$\cos \theta = 0.71$ $\Delta N = 0.041$ cm.,

agreeing as nearly as may be expected with the experimental datum. The apparatus thus serves incidentally for investigating such properties of spectrum lines as Michelson in particular has detected.

With white light the interference grid rarely reappears rhythmically nor does it correspond to the zero'th period of figure 4, i.e., to the ovals for sodium light. It is usually exactly of the size of some higher order, in yellow light, as at "*wh*" in fig. 4. It does not require such sharp horizontal and vertical coincidence of the superposed images, as the spectrum fringes.

In a flash of the arc, showing many sharp spectrum lines in all colors, each of the lines gives evidence of the phenomenon; i.e., if the residual fringes are oblique, each such line is strongly helical in appearance.

Hence the equation for the residual fringes may be assumed to be

$$n\,\lambda = (e-e')\,[\mu\cos(r-\alpha) - \cos i]$$

when e and e' are the thicknesses of the two half silver plates, μ their index of refraction, i the angle of incidence, r the angle of refraction of an incident ray, and where α is the outstanding angle between the faces of the differential glass wedge, $e-e'$ thick at the ray in question. The possibility of throwing these fringes into any order of size, their small extent, sharpness and great abundance of light constitute their value for measurement.

THE PROTEINS OF THE PEANUT, ARACHIS HYPOGAEA

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Communicated by R. Pearl, March 27, 1917

During the last ten years the culture of peanuts has increased rapidly in the United States. This increase is partly due to the fact that the boll weevil has made the growing of cotton unprofitable in various sections of the South and peanuts are now grown as a supplementary crop. Most of the peanuts thus produced are sold to the oil mills to be pressed for the oil which they contain. Shelled peanuts yield from 40 to 50% of oil. This edible oil compares favorably with olive oil and is used for culinary purposes and for making olemargarin. Press cake from shelled peanuts contains about 45% of protein (N x 6.25). This cake is ground to a meal which is rapidly finding favor as a cattle food. Peanut meal is now quoted at $35 per ton and peanut oil at $1.05 per gallon.

Previous to the present work, the only published experiments on the protein of the peanut seem to be those described by Ritthausen[2] in a paper which appeared in 1880. This author found that the proteins of the peanut consist chiefly of globulin and his analytical data led him to believe that only one globulin is present.

We have made fractional precipitations of the proteins extracted by sodium chloride solutions from oil-free peanut meal and have isolated two globulins, one of which is present only to a small extent. The globulin composing the greater part of the protein in the peanut is precipitated, when in 10% sodium chloride solution, by adding ammonium sulphate to 0.2 of saturation. To this globulin we have given the name *arachin*. After filtering off the arachin, the second globulin may be ob-